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*On the Structure and Affinities of the Amphiumidæ. By E. D. Cope.**(Read before the American Philosophical Society, February 5, 1886.)*

By all authors, the genus *Amphiuma* has been included in the same family division with *Protonopsis* and *Megalobatrachus* until 1866. At that time the writer of this paper proposed to separate it from the latter genera as the type of a family *Amphiumidæ*, while the other genera were placed in another family with the name *Protonopsidæ*. This course has not been followed by later writers; in the Catalogue of the British Museum by Dr. Boulenger (1882), for instance, the three genera being included in one family, the *Amphiumidæ*.

The reasons for keeping the *Amphiumidæ* distinct from the *Protonopsidæ* were stated to be the following:\*

**AMPHIUMIDÆ:** "An axial cranial bone (? vomer) in front of orbito sphenoids, and one forming palatal surface in front of parasphenoid. \* Pariëtals prolonged laterally, not reaching prefrontals. Vestibule, wall osseous internally. Premaxillaries consolidated. Occipital condyles on cylindrical pedestal."

**PROTONOPSIDÆ:** "No anterior axial cranial bone. \* \* Pariëtals and prefrontals prolonged, meeting and embracing frontals. Wall of vestibule membranous internally. Premaxillaries separated. Occipital condyles sessile."

The following observations were made on the *Amphiumidæ*: "The occipital condyles and temporo-cervical tendon are quite as in *Desmognathus*; they have not been previously described.† In *Amphiuma means* there is a minute not articulated bone on the suture between the o. o. frontalia and prefrontalia in the situation of the lachrymal. There are some approximations to *Cæcilia* in *Amphiumidæ*. It does not appear to have been noticed that the \* \* free margin of the frontal seems to foreshadow the overroofing of the orbit and temporal fossa seen in *Cæcilia*. There is also a very large foramen or canal passing through the o. maxillare from near its middle to the orbit, foreshadowing the *canalis tentaculiferus* of *Cæcilia*: a narrow one occurs in the same situation in *Protonopsis*. Further the prominent horizontal anterior inferior processes of the vertebral centra are the same in *Amphiuma* and *Cæcilia*."

Occasion for the revision of these views having presented, the following facts and conclusions have been reached.

The characters assigned as above to the two families *Amphiumidæ* and *Protonopsidæ* are abundantly sufficient for retaining them as distinct. The form of the occipital condyles might be excepted from this estimate, and the axial bone in front of the parasphenoid proves to be abnormally cut off in the specimen then examined. The *Protonopsidæ* agree with other

\* Journal Academy Philadelphia, 1866, p. 104.

† They were described by Dr. J. G. Fischer, Anatomisch. Abhandl. üb. Perennibranch. u. Derotrem. Erstes Heft, p. 61 1864.

Urodela in all of the characters given, except in the exclusion of the frontals from the supraorbital border, and in the membranous characteristic of the internal wall of the vestibule. The Amphiumidæ differ from other Urodela in the presence of a large ethmoid bone (the one referred to as ? vomer in the diagnosis above quoted), in the presence of temporal ridges, and of two anteriorly directed hypapophyses of the precaudal vertebrae.

It is interesting to notice that three of the four characters just cited are shared by the Cæciliidæ. The presence of the ethmoid is of especial importance, as it is an element constantly wanting in the Urodela. I have not found it in *Desmognathus*, *Anaides*, *Spelerpes*, *Amblystoma*, *Salamandra*, nor *Protonopsis*; nor is it present in *Necturus* or in *Siren*. It is, on the contrary, always present in Cæciliidæ\* (see Plate v, E). The double anterior hypapophyses are otherwise confined to the same family.

The Cæciliidæ are generally regarded as representing a distinct order, which bears the names Apoda, or Gymnophiona. The definition given to this order by Mr. Boulenger† is: "No limbs; tail rudimentary. Males with an intromittent copulatory organ. Adapted for burrowing." Of these definitions none is of ordinal value. The tail in some species is distinct. The intromittent copulatory organ in *Dermophis mexicanus*, *Gymnopsis proximus*, and *Herpele ochrocephala*, is not an especial organ, but is merely the everted cloaca. The hard papillæ observed by Günther‡ in the *Ichthyophis glutinosus* are wanting in the above species. The protrusion of the cloaca is effected by two especial muscles, which are wanting in Amphiumidæ. As to limbs, their extremely rudimentary character in Amphiuma is well known. To regard their condition as indicating ordinal separation from the Cæciliidæ is not in accordance with our practice in similar cases in the Reptilia, as in the order Lacertilia. The characters of these parts and their supporting arches not having been heretofore given, I describe them below.

I have endeavored to sustain the order Gymnophiona by the character of the fusion of the nasal and premaxillary bones found in the majority of the genera.§ But Stannius|| shows that these bones are distinct in *Ichthyophis*. Huxley states (*Anatomy of Vertebrate Animals*, p. 155) that in *Ichthyophis glutinosus* a distinct bone nearly encircles the orbit. This he compares to the supra and postorbital bones found in the Stegocephali. But in *Chthonerpeton*, *Cæcilia*, *Dermophis* and other genera, this bone forms part of the maxillary, so that it is not characteristic of the family, and may not be homologous with the bones which occupy the same position in Stegocephali. Wiedersheim calls it maxillary.

With these facts in view I have united¶ the Cæciliidæ with the Urodela,

\* See Wiedersheim, *Anatomie der Gymnophionen*, Jena, 1879.

† Catalogue of the British Museum, 1882, p. 88.

‡ Reptiles of British India (Roy. Society), p. 441.

§ *American Naturalist*, 1884, p. 26.

|| *Zoötomie der Amphibien*, 1856, p. 44.

¶ *American Naturalist*, 1885, p. 244, note.

a proposition which I now fully believe to be sustained by the evidence. *The Cæciliidæ is a family of Urodela, connected with the typical forms through the Amphiumidæ.*

Wiedersheim (l. c. p. 95) has attempted to trace the ancestry of the Cæciliidæ to the Stegocephali of the Carboniferous period, from which he supposes them to have arisen by a process of degeneration. He remarks that in order to demonstrate this proposition it is only necessary to discover a type with rudimental limbs which shall connect the two.

That the Cæciliidæ is a type which has resulted from a degeneration, I have also proposed,\* but I have derived them from the Urodela rather than from the Stegocephali direct. They have, like Amphiuma, essentially the same cranial structure as the Urodela, which is widely different from that of the Stegocephali, in the absence of the intercalare, supratemporal and postorbital bones. And these characters are fully maintained in various genera of Stegocephali which have rudimental limbs. Amphiuma then is the annectant type with rudimental limbs, which Dr. Wiedersheim sought for. The circumstance that his eyes were turned towards the Stegocephali indisposed him to recognize this fact.

The only portion of the shoulder girdle of this genus which is ossified is the scapula. The coracoid cartilages of opposite sides are distinct from each other, and there is a production of the præcoracoid region. The humerus is truncate at both extremities, making its articulations with cartilage only. The carpus is undivided cartilage. The osseous ilium is quite short and slender; it has a long superior cartilaginous portion, which is attached to an equally long cartilaginous sacral rib. The inferior element is an undivided plate, which is wider than long, and presents an obtuse angle anteriorly. The posterior portion of each is occupied by a round discoid ossification, which forms the posterior border, but does not reach either the acetabulum or its fellow. The femur is rather long and has a distinct trochanter, but no head nor condyles. The articulations are cartilaginous, as is the tarsus, which is also undivided. The tibia and fibula are about one-sixth the length of the femur, and the fibula is a little shorter and more slender than the tibia. The phalanges in both feet are well ossified.

The general characters of these parts are described in Stannius' Handbuch der Zoötomie,† but only as included in the definitions of the order to which Amphiuma is referred.

#### PLATE VI.

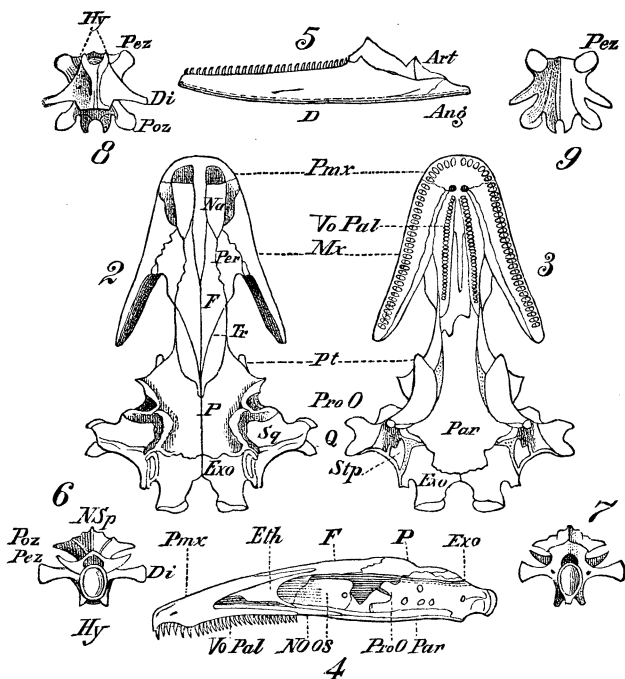
*Amphiuma means* Gard. One-third natural size. Original. From Georgia.

Fig. 1, skull, left side.

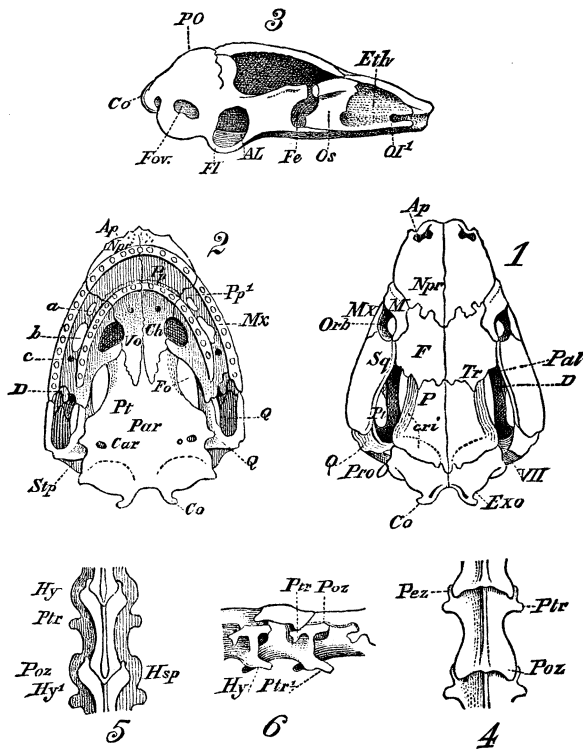
Fig. 2, do. from above.

\* American Naturalist, 1885, p. 244.

† Rostock, 1856.



*Amphiuma means* Gard.



*Chthonerpeton indistinctum* R. and L.

Fig. 3, skull, from below.

Fig. 4, do. right half, from within.

Fig. 5, left mandibular ramus, external view.

Figs. 6-9, an anterior dorsal vertebra; fig. 6, front; 7, rear; 8, bottom; 9, top.

#### PLATE VII.

*Chthonerpeton indistinctum* R. and L. Three-eighths nat. size. After Wiedersheim. From Brazil.

Fig. 1, skull, from above.

Fig. 2, do. from below.

Fig. 3, do. left half, from within.

Figs. 4-6, one and parts of two other vertebræ; 4, from above; 5, from below; 6, right side.

#### EXPLANATIONS OF LETTERS.

*Pmx.*, Premaxillary.

*Max.*, Maxillary.

*Na.*, Nasal.

*Npr.*, Nasopremaxillary.

*Pef.*, Prefrontal.

*F.*, Frontal.

*P.*, Parietal.

*Tr.*, Temporal ridge.

*Sq.*, Squamosal.

*Exo.*, Exoccipital.

*Pro O.*, Prootic.

*OS.*, Orbitosphenoid.

*Eth.*, Ethmoid.

*Par.*, Parasphenoid.

*VoPal.*, Vomeropalatine.

*Pt.*, Pterygoid.

*Stp.*, Stapes.

*Q.*, Quadrate.

*Co.*, Occipital condyle.

*Art.*, Articular.

*Ang.*, Angular.

*D.*, Dentary.

*Di.*, Diapophysis.

*Pez.*, Prezygapophysis.

*Poz.*, Postzygapophysis.

*Hy.*, Hypapophysis.

*Hsp.*, Hypapophysial spine.

*NSp.*, Neural spine.

*Ch.*, Posterior nares.

*Ap.*, Anterior nares.

*a*, Naso-palatal foramen.

*b*, " " "

*c*, " " "

*Car.*, Carotid foramen.

*Orb.*, Orbit.